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PRINCIPLES OF DESIGNING PROPORTIONING LINES FOR BATCH-PREPARATION SHOPS

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Principles of designing proportioning lines for glass-batch preparation are considered.

In introducing contemporary quality-control systems at glass factories, special attention is paid to the basic issue, i.e., the process of batch preparation. It is obvious that proportioning equipment is the determining factor of product quality at the stage of batch preparation. The parameters of a dosing line influencing batch quality are the following: proportioning accuracy, weighing stability in any time interval, and reliability and longevity of equipment.

Proportioning accuracy and weighing stability are the deciding factors. It is impossible to obtain an ideal-quality batch in practice; therefore, a batch composition always has certain deviations from a preset formula. For instant, requirements on top-grade batch permit a weight deviation for one of the components within the limits of 0.3% of the estimated value. The total error is made up of two components, i.e., systematic and random errors. Each of these components should not exceed one-third of the total error.

The systematic error largely depends on the error of the dosing complex weigher. In our case, this is the error of the strain-gage maters. Strain measurements have made considerable progress lately. Up-to-date strain-gage sensors can bring systematic error down to 0.02 – 0.06%, which is sufficient for producing grade I batch.

It is more difficult to determine random errors. To determine the properties of friable material, one has to take into account its different parameters, such as adhesion, autohesion, and cohesion, in order to prevent sticking and clotting of material, as well as arch- and tube-formation. Fluidity of material is affected by different chemical, physical, and electric forces of different natures; these forces are oriented in different directions, which prevents an accurate description of static and dynamic behavior of material. Theoretically, the outflow of raw material can be determined only with a certain degree of probability. In practice, up to 15% of raw material may become suspended in the bunker.

Hence, our aim is to cut off all random errors. To do this, we load material into the weighing bunker (120% of the weight required) and then gradually dispense a required portion via the lower feeder (implement differential weighing). We are not interested in how much material will be suspended in the bunker or how much dust will settle on the weigher; we know that a day later or a month or a year later the dosing set will dispense 100% of the portion required. The concept of proportioning by means of the lower feeder makes it possible to reduce the total error of dosing complexes to 0.2%, which corresponds to precision class 0.2 (GOST 10223–97).

Specific features of friable materials determine special rules. The first one is: The higher the weight of friable material weighed, the lower the error. Theoretically, with an equal error of the strain gage, portions of 100 kg or 300 kg should be dispensed with an equal relative error. However, in practice the weighing accuracy of the "lightweight" proportioner is affected by vibrations of the neighbor machinery and by natural vibrations of the proportioning complex, and when a substantial weight of a batch component is accumulated by means of intermediate portions, the random error component becomes accumulated. Therefore, Western manufacturers of dosing equipment tend to provide for single weighings of 1000- or 1500-kg portions. The designers at the Stekloavtomatika Company take into account this trend: all dosing bunkers are intended for weighing a complete dose of a batch component without intermediate portions.

The reliability of equipment should be regarded as an element of the technological system of the proportioning division. The technological system in this case includes all instruments (proportioning equipment, control system) used for producing batch of preset quality in required volumes.

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A great number of elements in the technological system, in which failure of any element may result in failure of the whole system, has a negative effect ion on reliability. Often specialists in batch-preparing plans intuitively increase the reliability of the system by introducing standby and spare elements. In other words, they install additional proportioning complexes and mixers or, better still, parallel mutually replaceable dosing lines.

The most complicated and, accordingly, the least reliable components of the proportioning complex are screw feeders and electric and pneumatic drives. Screw feeders developed by our company have been used for many years at glass factories and have proved reliable. To monitor the performance of gearheads, the control system is equipped with feedbacks that constantly monitor the main parameters of the motor. A smooth start-up and, in necessary cases, smooth deceleration of the electric motor completely remove the problem of the impact of start-up moments on mechanical equipment. Pneumatic cylinders in all possible cases exercise smooth motion. The dosing complexes developed by us have sufficient reliability.

For a control system, it is better to use the term "performance quality." A programmable controller has to receive a high-quality (non-distorted) signal from the strain gage transducer, perform logical and arithmetic operations in accordance with the program, and at the right moment send signals to the executive mechanisms while constantly monitoring its own performance and the performance of the whole equipment.

The Stekloavtomatika JSC together with the KIP-Servis Company have developed an automated control system for the batch production process. The system proposed is based on an Allen-Bradley controller (ControlLogix), weight-measuring instruments made by Hottinger, frequency electric drives produced by Telemechanique, and an IBM PC computer. The control system is developed using mounting parts and equipment of such well-known companies as Siemens, Legrand, and Telemechanique. The use of imported equipment is motivated by requirements for high reliability, comfort, and service simplicity. Furthermore, troubleshooting options and reliable performance of the system, especially that of executive mechanisms, make it possible to substantially decrease idle time of the technological equipment (losses caused by one idle day are comparable to the cost of the whole control system).

The longevity of a proportioning line is the maximum service life determined by going beyond the admissible proportioning accuracy limits and an ultimate state, in which the total time and financial costs needed to restore the line to the working state are not justifiable. One of the components of longevity is the original life before failure of each mechanism making part of the proportioning complex. Let us consider an example.

The guaranteed service run of a pneumatic cylinder is 42 km. With the average batch-preparation cycle equal to 10 min, a cylinder will cover this run in 7 years, but only if the pneumatic cylinder performs once per cycle. However, if the dosing system accumulates a required weight in 2 – 3 intermediate doses, the guaranteed run will accordingly decrease by half or to one-third. Therefore, in designing our dosing lines, we are guided by the following principle: The smaller the duration and frequency of switching-on, the longer the service life.

The use of the control system proposed provides for the following functional possibilities and characteristics:

– stabilization of quality of batch prepared;

– prompt replacement of setting depending on the type of material;

– high reliability;

– future upgrade of the control system without replacing the equipment;

– development of the top level of the control system, implying installation of computers (one or several) and connection with the controllers.

Such control system is expected to improve and stabilize product quality, decrease the service cost, and improve labor efficiency. An important result of implementation of this system is bringing production to international levels and the possibility of certification according to ISO 9001.

The dosing lines developed by the Stekloavtomatika specialists provide for smooth but highly efficient work of the dosing equipment with optimum accuracy and stability parameters and sufficient reliability and service life.